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Neuroprosthetics

GROUP9：施翔舜、蘇健智、陳毅明

Definition

“Any biomedically engineered device designed to be linked to the peripheral or central nervous system and enhance the cognitive, motor, or sensory abilities of an organism.”

Sensory prostheses

- cochlear implant, allow the deaf to hear.
- artificial retina, allow the blind to see.

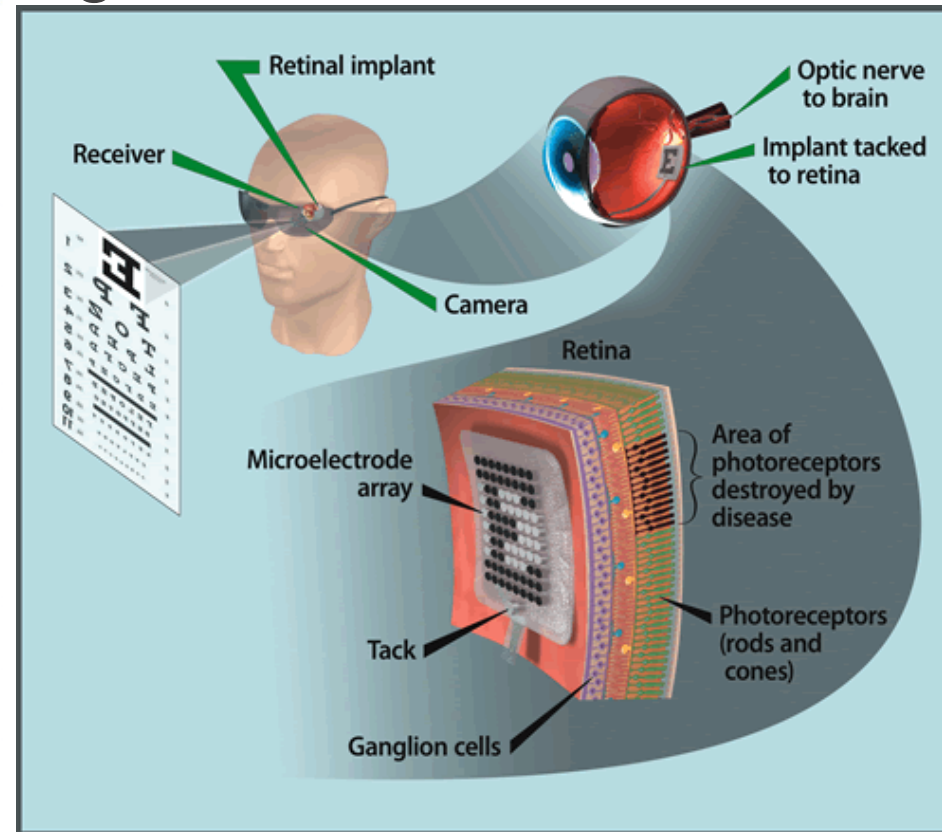
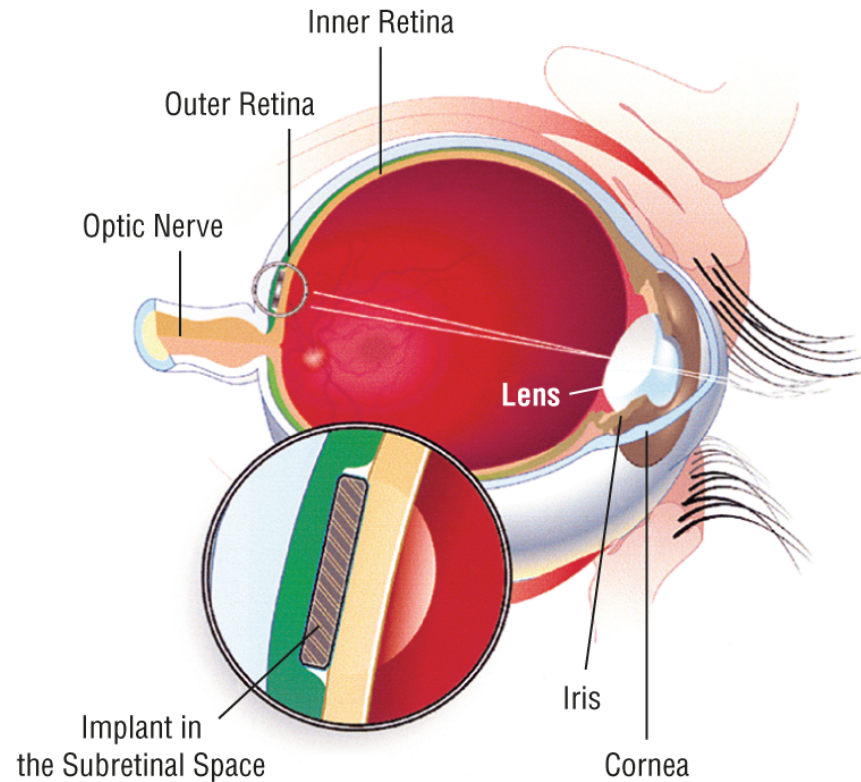
Cochlear implant

Microphone, filters, stimulators
Replace the function of hair cell



Artificial retina

ASR(Artificial silicon retina), Argus II Retinal Prosthesis



Motor prostheses

motor prostheses help regulate or stimulate malfunctioning motor functions.

Motor prostheses

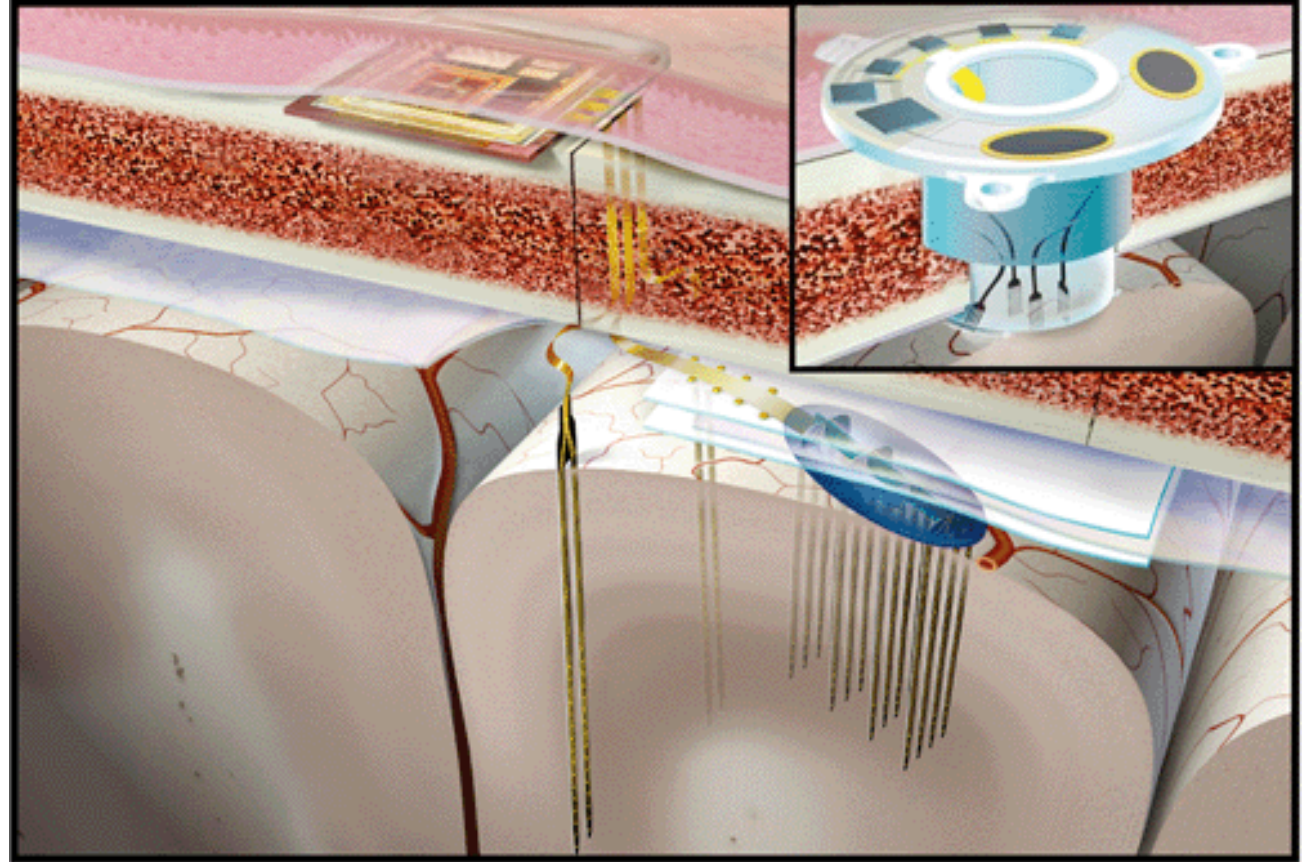
- pacemaker
- conscious control of movement
 - indicators
 - upper limbs
 - Lower limbs

Hugh Herr

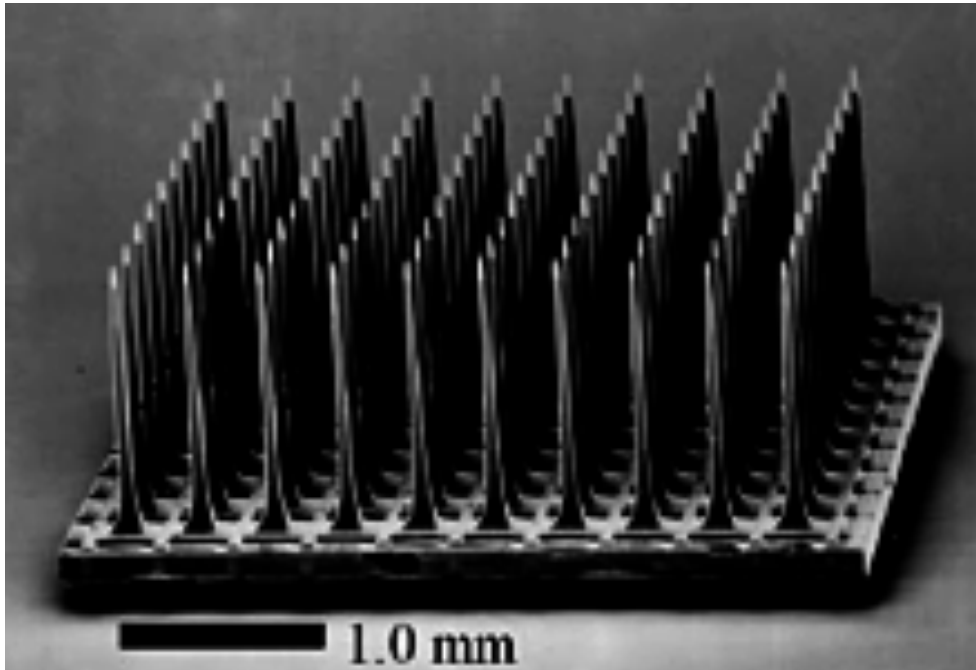
- A rock climber
- Associate Professor of Media Arts and Sciences in MIT
- In 1982, he was amputated below the knees because of frostbite
- BiOM

Neural implant

Thin microelectrode array
detect neuro signal
connect to the cortex directly

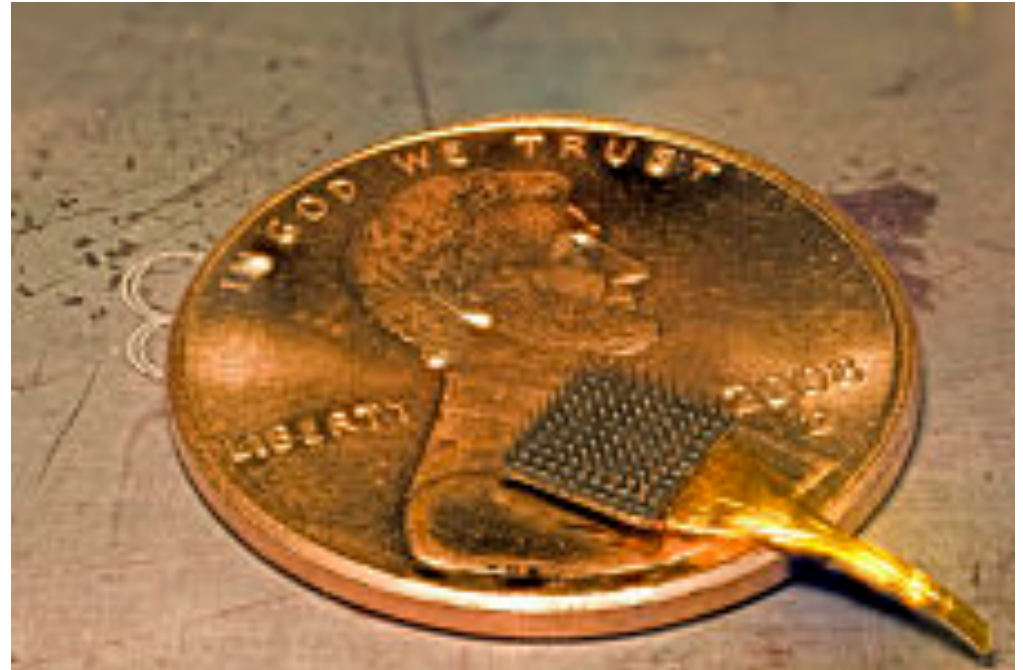


Neural implant



4mm*4mm

100 electrodes



Brain gate



Cognitive prostheses

Prostheses that seek to restore cognitive functions of the nervous system lost due to injury, disease, tissue loss, etc.

Most of them are still in the experimental stage

Deep Brain Stimulation

Is applied to treat various disorders including:

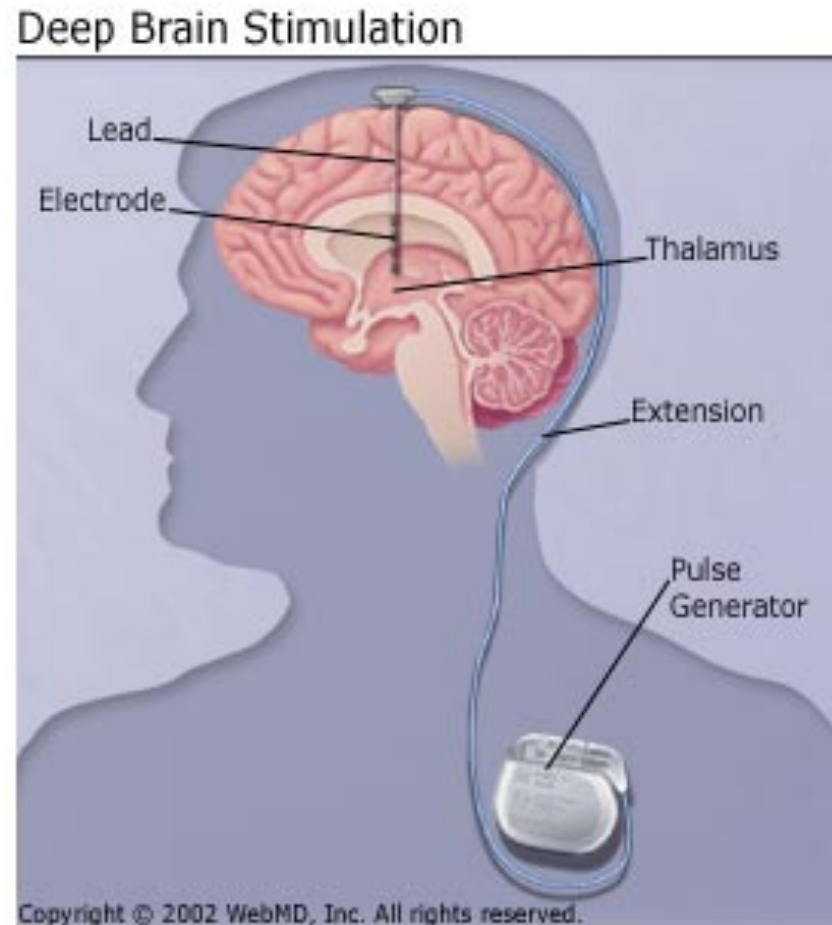
- Parkinson's disease
- essential tremor
- dystonia
- chronic pain
- major depression
- Obsessive-compulsive disorder(OCD)

Deep Brain Stimulation

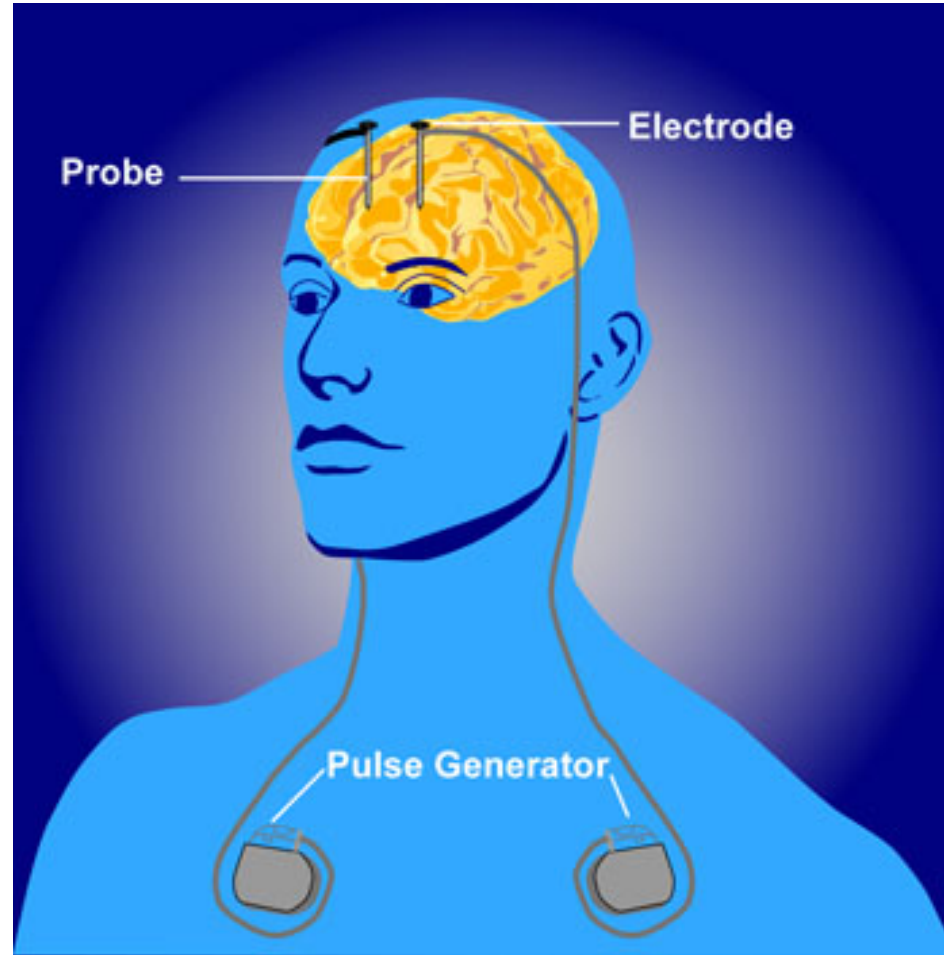
Components:

- Implanted Pulse Generator (IPG)
- Lead
- Extension

Deep Brain Stimulation



Deep Brain Stimulation

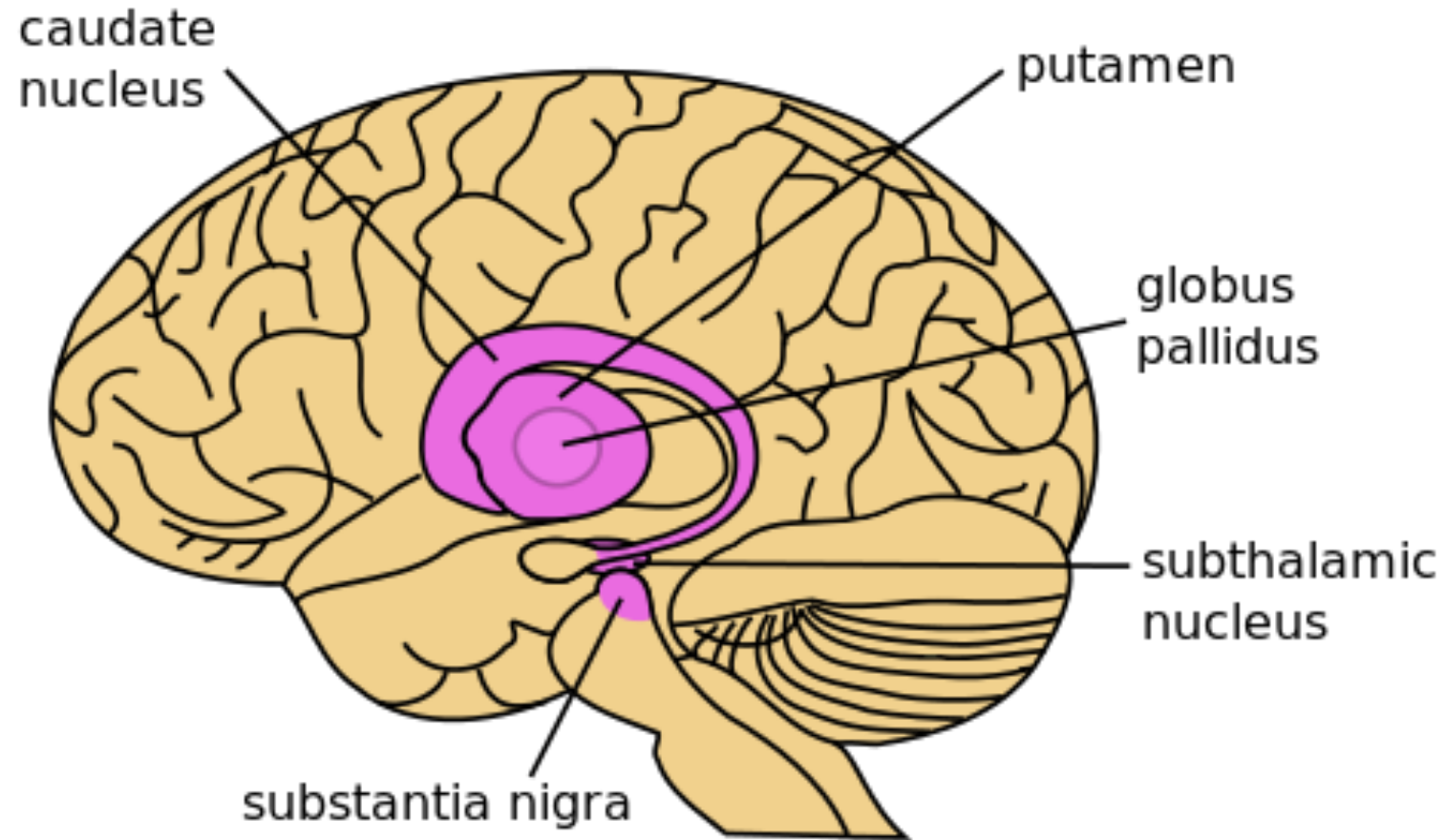


Deep Brain Stimulation

Application to Parkinson's Disease

- Does not cure, but helps manage the symptoms
- Only used when cannot be controlled by medication or when medication causes severe side-effects
- Sends high frequency electrical impulses into the target site
- Electrodes, in most of the cases, are placed in the subthalamic nucleus
- Mechanism still debated

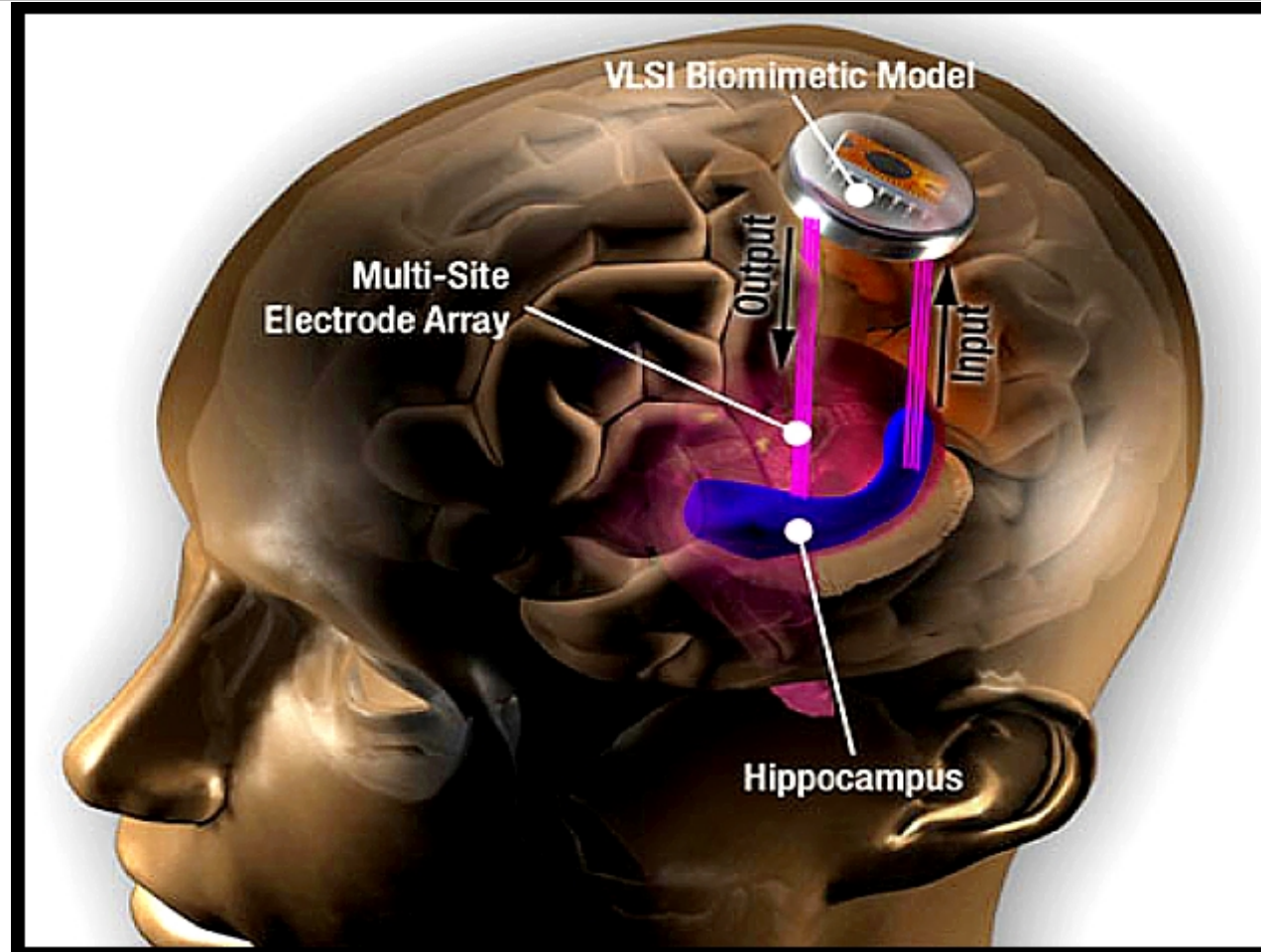
Deep Brain Stimulation



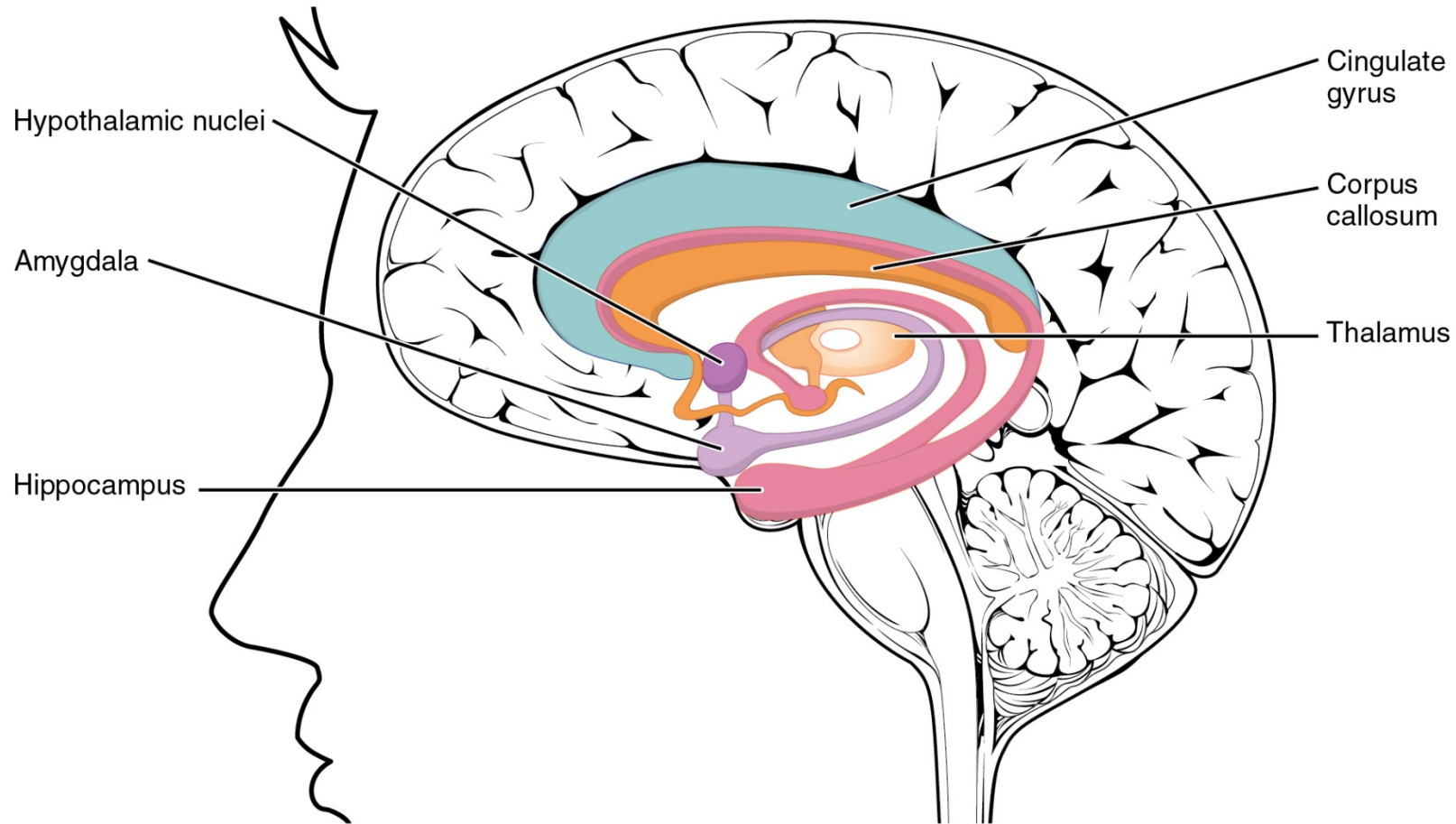
Hippocampal Prosthesis

- Primarily developed to cure Alzheimer's disease
- Still under development
- Have undergone tests on non-human primates successfully

Hippocampal Prosthesis



Hippocampal Prosthesis



Companies and Products

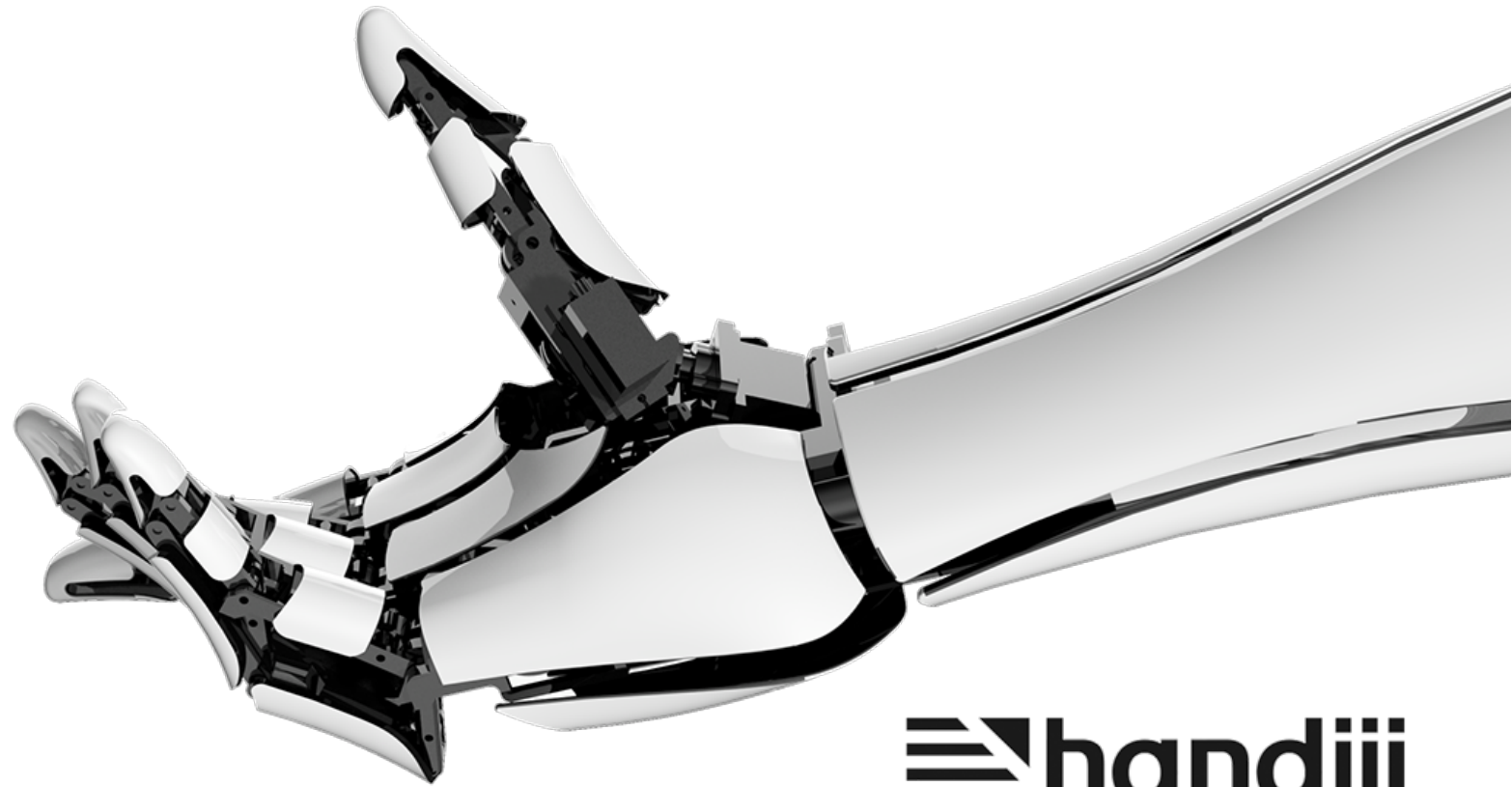
exiii – handiii

BionX – BiOM Ankle

Medtronic and Advanced Bionic – DPS

Cyberkinetics - BrainGate

Companies and Products - handiii



 **handiii**

Accessible myoelectric hand

Companies and Products – BiOM Ankle



Some milestone about hearing

In 1957, **A. Djournio**, a Parisian professor of medical physics, and **C. Eyries**, a Parisian otologist, restored hearing to a deaf patient with total bilateral cholesteatomas by **electrically stimulating acoustic nerve fibers still present in the inner ear**.

Though that's not their original goal.

They had in fact been seeking to remobilize the frozen facial traits of a patient with cholesteatomas in both ears.

They publish their observation in the French journal Presse Médicale.

They stop the experiment not after long.

In 1961, a patient gave **William House**, a Californian otologist, a copy of a Los Angeles article describing the work of the Paris researchers.



House standardized the surgical procedure and stably positioned the stimulatory electrode by **threading it through the round window in the cochlear channel.**

It have some problem and the recipient can only recognize rhythms of the speech.

In 1966 **B. Simmons** (Palo Alto, CA) performed the first temporary human implantation of a multichannel system in the trunk of the auditory nerve itself, in a deaf volunteer.

Able to generate sensations of **different frequencies** depending on the origin of the stimulated fibers on the cochlear keyboard.

In 1973, CH Chouard together with P. MacLeod showed that electrical stimulation of 8 to 12 electrodes allowed the recipients to perceive different frequencies.

In seven therapeutic operations on adult cases of acquired total bilateral deafness, **speech recognition was usually relearned within a month or two.**

Technological evolution and competition leading to a consensus on the best approach (1976-1997)

On 16 March 1977, Bertin filed **Patent No. 77/07824**, based on the physiological criteria of MacLeod and making two simultaneous claims: 1) sequential transmission to the cochlea of an indeterminate number of frequency bands, and 2) transmission of all the sound information. The first results were presented at the XIth World ENT Conference in Buenos Aires, and were quickly published.

In 1984, **the U.S. Food and Drug Administration** approved the Australian implant for use in adults.

In 1994, Med-el presented the world's first electrode array capable of stimulating the entire length of the cochlea to allow a more natural hearing.

After 1977, all manufacturers have since applied the principles of the Bertin patent defined **by P. MacLeod and CH Chouard**.

present

There are two communities, French National Ethics Committee and Abbe de l'Épée, that are in leading.

They are striving to refine the criteria of choice between the cochlear implant and the use of sign language.

Obstacles

- Nerve signal interpretation
- Size of implant
- Battery lifetime
- MRI-Compatibility
- Biocompatibility
- Mathematical modeling
- Safety risks

Future Potentials and Possibilities

Implants that self-recharge using bioenergy

Memory export/import

Controlling machinery with thoughts

Expanding brain capacity

And many many more...

Reference

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Q&A
